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On the association of carangid juveniles, *Alepes djedaba*, with the jellyfish *Rhizostoma pulmo*

by

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Résumé. – Sur l’association de carangidés juvéniles, *Alepes djedaba,* avec la méduse *Rhizostoma pulmo*.

Nous avons étudié l’association poissons-méduses à partir de 99 spécimens de méduses, récoltées dans sept sites différents durant l’été 2015. Les méduses recueillies étaient *Rhizostoma pulmo* (Macri, 1778) et les poissons juvéniles associés à ces hôtes ont été identifiés comme *Alepes djedaba* (Forsskål, 1775). Le carangidé *A. djedaba* est souvent étroitement associé à de nombreuses espèces de grandes méduses scyphozoaires. Cette étude fournit des informations de base sur les distributions spatiales de l’association poissons-méduses, fondées sur des observations réalisées dans la partie ouest de la mer de Marmara, en Turquie.

Keywords. – Carangidae - *Alepes djedaba* - *Rhizostoma pulmo* - Jellyfish - Sea of Marmara - Symbiosis.

The Sea of Marmara is a unique inland sea located in the mainland within Turkey property as a whole and the Turkish Straits System (TSS), composed of the Dardanelles and the Bosporus, connecting the Black Sea with the Mediterranean waters via the Sea of Marmara.

A two-layer system of currents flowing in opposite directions occurs in the TSS; the Black Sea originated low salinity surface waters disperse on the surface and reach the Aegean Sea via the Dardanelles, while high salinity and warmer waters of the Mediterranean build the deeper layer and reach the Black Sea via the Bosporus. This water exchanges affect the hydrographical and biological characteristics of the Sea of Marmara by the way of the Mediterranean Sea via the Aegean Sea or by the way of the Black Sea.

The jellyfish-fish association is regarded as a temporary symbiosis believed to protect the fish in the early period of their lives from predators. Status of young fish, sheltering under the umbrella, in the subgenital cavities and grooves at the base of the mouth arms of jellyfish and taking refuge when alarmed, is well known. The fish associated with jellyfish commonly belong to the families Carangidae and Gadidae (Jones, 1960).

The juveniles of *Alepes djedaba* (Forsskål, 1775) are commonly found in association with the medusa *Rhopilema nomadica* described by Galil *et al*. (1990), taking shelter under its umbrella and gathering around the filamentous mouth arms. This is also a common action for *Caranx* spp.: Panikkar and Raghu Prasad (1952: 295) reported the association between juveniles of *Caranx kalla* (Cuvier & Valenciennes, 1833) and the jellyfish *Rhopilema hispidum* (Vanhöffen, 1888): “The medusae were always found to be followed by a group of young fish, which when disturbed take shelter underneath the bell.” In another report, Bapat and Ragu Prasad (1952: 111) reported: “427 specimens of *C. kalla* varying from 8.25-55 mm in length were moving in small schools around the large medusa belonging to the species *R. hispidum*.”

Two species of scyphozoan jellyfish commonly occur in the Sea of Marmara: the barrel jellyfish *Rhizostoma pulmo* (Macri, 1778) and the moon jelly *Aurelia aurita* (Linnaeus, 1758) (Mavili, 2008). *R. pulmo* is a cosmopolitan genus, particularly abundant in the coastal waters of the Sea of Marmara, although occurring also in the adjacent connected seas, the Mediterranean and the Black seas.

Here we report on juvenile shrimp scads *A. djedaba* association with the jellyfish *R. pulmo* in the west part of the Sea of Marmara.

MATERIALS AND METHODS

Alepes djedaba and *Rhizostoma pulmo* relations were examined during the 2015 summer; the specimens were collected between 12.08.2015 and 09.09.2015, in seven different stations (Fig. 1, Tab. I) in the Sea of Marmara. The depth of the stations ranged from 3 to 16 m and the horizontal visibility was around 10 m. *R. pulmo* samples are hauled using hand net with 40 cm diameter frame and 60 cm of length, with 5 mm mesh size. Fifteen *R. pulmo* samples were collected in each station, except in station 5a. In each station, samples were collected at random, transferred in a transparent bucket to control the juvenile fish sheltered under the umbrella. The juveniles are counted and released gently back with the jellyfish together. After releasing, video recording of the *R. pulmo* and

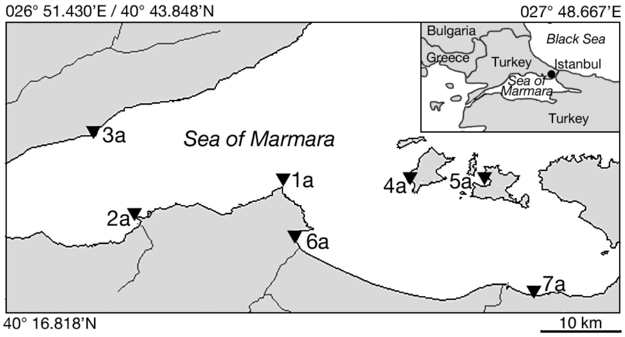

Figure 1. – Station locations: map of the sampling stations in the Sea of Marmara.

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Table I. – Location table with the coordinates of stations, depth, and working date for each station.

Station	Coordinates	Depth (m)	Date [Time]
1a	40°28.917'N: 027°17.300'E	16	12/08/2015 [16:06]
2a	40°25.750'N: 027°03.467'E	6	19/08/2015 [10:48]
3a	40°33.333'N: 026°59.500'E	3	21/08/2015 [11:33]
4a	40°29.083'N: 027°28.983'E	11	24/08/2015 [14:16]
5a	40°29.017'N: 027°35.983'E	4	02/09/2015 [12:16]
6a	40°23.600'N: 027°18.450'E	8	03/09/2015 [17:49]
7a	40°18.500'N: 027°40.683'E	9	09/09/2015 [11:33]

its *A. djedaba* juveniles captured was done by free swimming in the natural environment. Some fish were killed for identification by using heavy anesthetic MS222 and deposited with barcode nr: 160-1AL.

At the same time, the overall density of *R. pulmo* individuals in sampling areas was also visually recorded. The visible individuals, from the port side of the boat approximately with 90° sight angle from 3 m eye height level from the sea surface, are visually counted (mean Secchi-disc value was 7.5 m) and the occurrence (O) of *R. pulmo* was counted to identify the species abundance; accordingly, each species was evaluated either as abundant (20 ≥ O ≥ 10), common (10 > O ≥ 5) or rare (O < 5). All data were collected and processed via HIDRO-QL (Artüz, 1990) software.

Environmental data

Oceanographical parameters were measured *in situ* with a CTD YSI.

6600 V2 multi-parameter data sonde with additional dissolved oxygen (DO) and turbidity (Nephelometric Turbidity Unit, NTU) probes in the sample stations from the surface (0.5 m) to the deepest section of the station; Secchi-disc was measured with a standard 20 cm diameter black/white disc and Forel scale value was inspected with octet comparator with standard colours. Thereafter, data were stored and processed in the Hidro-QL database with the corresponding software.

RESULTS

During the study, 99 *R. pulmo* were collected from seven different stations and a total of 110 sheltered *A. djedaba* juveniles, between 34 mm and 43 mm TL (Figs 2, 3), were recorded. A maximal number of three sheltered individuals per jellyfish was observed, corresponding to 7.1% of the collected *R. pulmo* specimens. The percentage of the empty *R. pulmo* specimens was 41.4%, and the percentages of jellyfish with two and single fish individuals were 38.4% and 13.2%, respectively. Numbers of sheltered individuals of *A. djedaba* following the sampling order of the host *R. pulmo* in each station are given in table II. Barrel jellyfish abundance was high in most stations, except in station 2a (common) and in station 5a (rare). The abundance of barrel jellyfish individuals visually recorded along with the environmental parameters is given in table III. Additionally, some parts of the copy of the video record done after the release of the jellyfish and their associated fish are given as supplementary material (3).

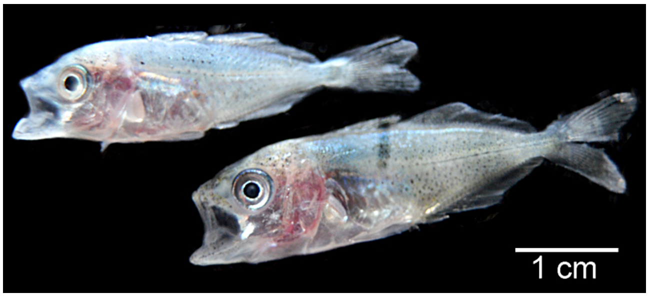

Figure 2. – Two *Alepes djedaba* juveniles

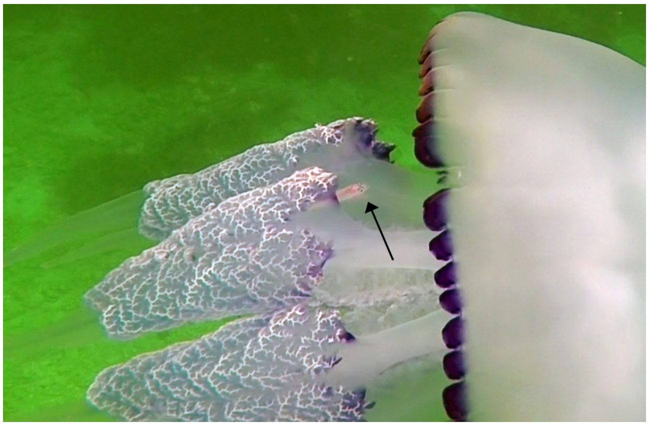

Figure 3. – A sheltered *Alepes djedaba* (arrow) among the *Rhizostoma pulmo* mouth arms in the natural environment.

Table II. – Number of sheltered individuals of *Alepes djedaba* against the sampling order of the host *Rhizostoma pulmo* in station basis. St.: station; *R.p*: *R. pulmo*; *A.d*: *Alepes djedaba*.

St. 1a		St. 2a		St. 3a		St. 4a		St. 5a		St. 6a		St. 7a	
R.p	*A.d*	*R.p*	*A.d*	*R.p*	*A.d*	*R.p*	*A.d*	*R.p*	*A.d*	*R.p*	*A.d*	*R.p*	*A.d*
1	2	1	1	1	2	1	2	1	2	1	2	1	2
2	0	2	2	2	0	2	0	2	0	2	2	2	2
3	1	3	0	3	0	3	2	3	3	3	0	3	2
4	0	4	0	4	0	4	0	4	0	4	2	4	2
5	2	5	0	5	2	5	1	5	3	5	2	5	2
6	3	6	2	6	0	6	0	6	0	6	0	6	1
7	0	7	2	7	2	7	0	7	0	7	1	7	1
8	2	8	3	8	2	8	2	8	0	8	2	8	0
9	0	9	0	9	0	9	0	9	2	9	0	9	0
10	0	10	1	10	0	10	0	–	–	10	1	10	1
11	2	11	2	11	2	11	2	–	–	11	2	11	2
12	3	12	0	12	0	12	3	–	–	12	0	12	0
13	0	13	2	13	3	13	0	–	–	13	1	13	0
14	2	14	2	14	2	14	1	–	–	14	0	14	2
15	0	15	0	15	2	15	1	–	–	15	2	15	1

Remarks. – During the observations of the fish-jellyfish association in the natural environment, it was monitored that the fish also played a vanguard role. During the observations underwater, most fish were located in front of the umbrella around but outside of the jellyfish until we were noticed. After noticing us, they swam

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(3) Video *A. djebdaba* and *R. pulmo* association.wmw. Available on our website: http://sfi.mnhn.fr/

Table III. – *Rhisostoma pulmo* traceability density regarding visual inspection and basic oceanographical parameters of surface layer (0.5-2 m) of the sampling stations. St.: station number; Depth: station depth; S-d: Secchi-disc depth; Forel: Forel scale value (Forel-Ule Scale); Sal ‰: Salinity value; Turb: Turbidity-Nephelometric Turbidity Unit (NTU); DO: Dissolved oxygen; *R.p* (O): *R. pulmo* traceability (abundant ($20 \geq O \geq 10$), common ($10 > O \geq 5$) and rare ($O < 5$)); *Tn*: total number of *Alepes djedaba* recorded in each station.

St.	Depth (m)	S-d (m)	Forel	Temp (°C)	Sal (‰)	Turb	DO (mg l^{-1})	*R.p* (O)	Tn
1a	33	7.0	5	27.1	22.6	0.4	5.6	abundant	17
2a	19	6.5	5	26.8	22.8	0.5	5.3	common	17
3a	4	–	6	26.5	22.4	0.2	6.2	abundant	17
4a	12	8.5	6	26.8	22.5	0.7	5.6	abundant	14
5a	14	9.0	5	26.4	22.3	0.3	5.7	rare	10
6a	11	6.5	5	26.2	21.9	1.1	5.1	abundant	17
7a	13	7.5	6	26.3	21.3	1.0	5.5	abundant	18

directly under the umbrella of jellyfish and disappeared and non free-swimming juveniles were observed.

All *R. pulmo* individuals inspected during the working period did not present any damage except one in station 3a, with one missed mouth arm, which did not include any sheltered fish.

DISCUSSION

The survival of juveniles of some pelagic fish species is considered as dependent on jellyfish since young individuals of these species are rarely found alone or recorded in the diet of pelagic-feeding fish (Nagabhushanam, 1964). Those particularly involved in this kind of relationship belong to the genus *Caranx* and are widely known. Ohtsuka *et al.* (2010) reported that *A. djedaba* is widely associated with many species of large jellyfish in tropical Asian waters.

Present observations show that a significant *A. djedaba* population is present in the Sea of Marmara, especially in the areas where *R. pulmo* is abundant. The first record of this species in the Sea of Marmara was a female *A. djedaba* of 116 mm total length on 28 August 2010 (Artüz and Kubanç, 2014). According to Bykov (1983), the recorded maximal length of this species is 400 mm TL. The occurrence of juveniles of *A. djedaba* and its association with jellyfish in the Sea of Marmara is also a significant proof of the adaptation of that Indo-Pacific originated fish in this region.

The Turkish Straits play a significant role of biological corridors in the biological variation of community structure of the Sea of Marmara in connecting oceanographically dissimilar adjacent watermasses, the Mediterranean Sea and the Black Sea. In the Sea of Marmara, *A. djedaba* is selecting *R. pulmo* as a shelter in its early stages of life, but this aspect needs further investigation since this species might prove fish recruitment by providing benefits to fish juveniles in terms of protection, and even of feeding opportunities in the Sea of Marmara ecosystem.

This study provides i) basic information about the spatial distribution of fish-jellyfish association during summer 2015 in the Sea of Marmara, ii) indicates the complexity of an ecosystem including jellyfish *R. pulmo*, rather simple ecological effect on fish shrimp scad *A. djedaba* group or a whole system, and iii) suggests a possible jellyfish-fish partnership habitat in the Sea of Marmara. This study is based on the monitoring of seven stations, which were studied during the summer 2015 (and ongoing), and gives an insight into the Sea of Marmara ecosystem, which may be useful for further researchers who works with the fish-jellyfish association, ecology and fisheries biology and fisheries management.

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